MECHANISMS OF SINGULARITY

DETERMINISTIC NECESSITY

SELECTIVE BOTTLENECK

RESTRICTIVE BOTTLENECK

PSEUDO-BOTTLENECK

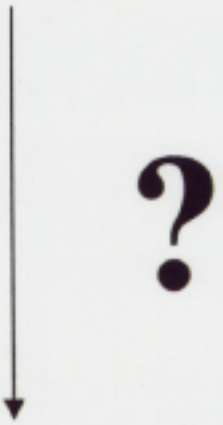
FROZEN ACCIDENT

FANTASTIC LUCK

INTELLIGENT DESIGN

ORIGIN OF LIFE

SPACE CHEMISTRY



?

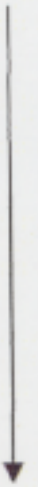
LUCA

(Last Universal Common Ancestor)

Cosmic Chemistry

CHEMISTRY

First RNA Molecules



CHEMISTRY
+ INFORMATION

LUCA

MOLECULAR SELECTION

(EVOLUTION IN THE TEST TUBE)

TEMPLATE

↓

REPLICATION

↓

MUTATIONS

↓

SELECTION

↓

FINAL PRODUCT

(OPTIMAL STABILITY + REPLICABILITY)

CELLULAR SELECTION

GENE

↓

REPLICATION

↓

MUTATIONS

↓

MODIFIED GENE PRODUCTS

↓

SELECTION

↓

FINAL GENE (CELL)

(MOST USEFUL GENE PRODUCT)

1. PRE-RNA STAGE

A) CHEMICAL FOUNDATION

(Protometabolism)

↓

B) FIRST POLYNUCLEOTIDES

(Gemisch)

↓

C) FIRST REPLICATABLE MOLECULES

(RNA)

↓

D) MOLECULAR SELECTION

(Eigen 's « Ur-Gen »)

BIRTH OF ENZYMES

1a. MUTATION OF RNA GENE

1b. NEW PROTEIN WITH ENZYMATIC ACTIVITY

1c. SELECTION OF MUTANT PROTOCELLS

↓

2. NEW MUTATION --> ENZYME --> SELECTION

↓

3. NEW MUTATION --> ENZYME --> SELECTION

↓

4. NEW MUTATION --> ENZYME --> SELECTION

⇣

300. FULL SET OF NEW ENZYMES --> METABOLISM

CONDITION OF SELECTION

ENZYME MUST BE USEFUL, i.e., MUST FIND SUBSTRATE (S) AND OUTLET(S) IN PROTOMETABOLISM

HENCE

PROTOMETABOLISM AND METABOLISM WERE CONGRUENT, i.e., FOLLOWED SIMILAR PATHWAYS

PROTEIN SEQUENCE SPACE

Peptides		
Length	Number	Total Mass
$n(am.ac)$	$20^n = 10^{1.3xn}$	$1.8\ n \times 10^{(1.3n-22)}$ g
10	$20^{10} = 10^{13}$	18 ng
20	$20^{20} = 10^{26}$	360 kg
30	$20^{30} = 10^{39}$	5.4×10^{15} kg (10^{-9} Earth)
50	$20^{50} = 10^{65}$	1.8×10^{17} Earths
100	$20^{100} = 10^{130}$	3×10^{54} Universes
200	$20^{200} = 10^{260}$	6×10^{184} Universes
300	$20^{300} = 10^{390}$	9×10^{312} Universes

THE FIRST PROTEIN ENZYMES WERE VERY SHORT

A) THE FIRST RNA GENES WERE 50 TO 100 NUCLEOTIDES LONG

1) Phylogeny of tRNAs

(Eigen & Winkler-Oswatitsch, 1981)

2) Maximum Length = Inverse of Replication Error Rate (2 to 1%)

(Eigen & Schuster, 1977)

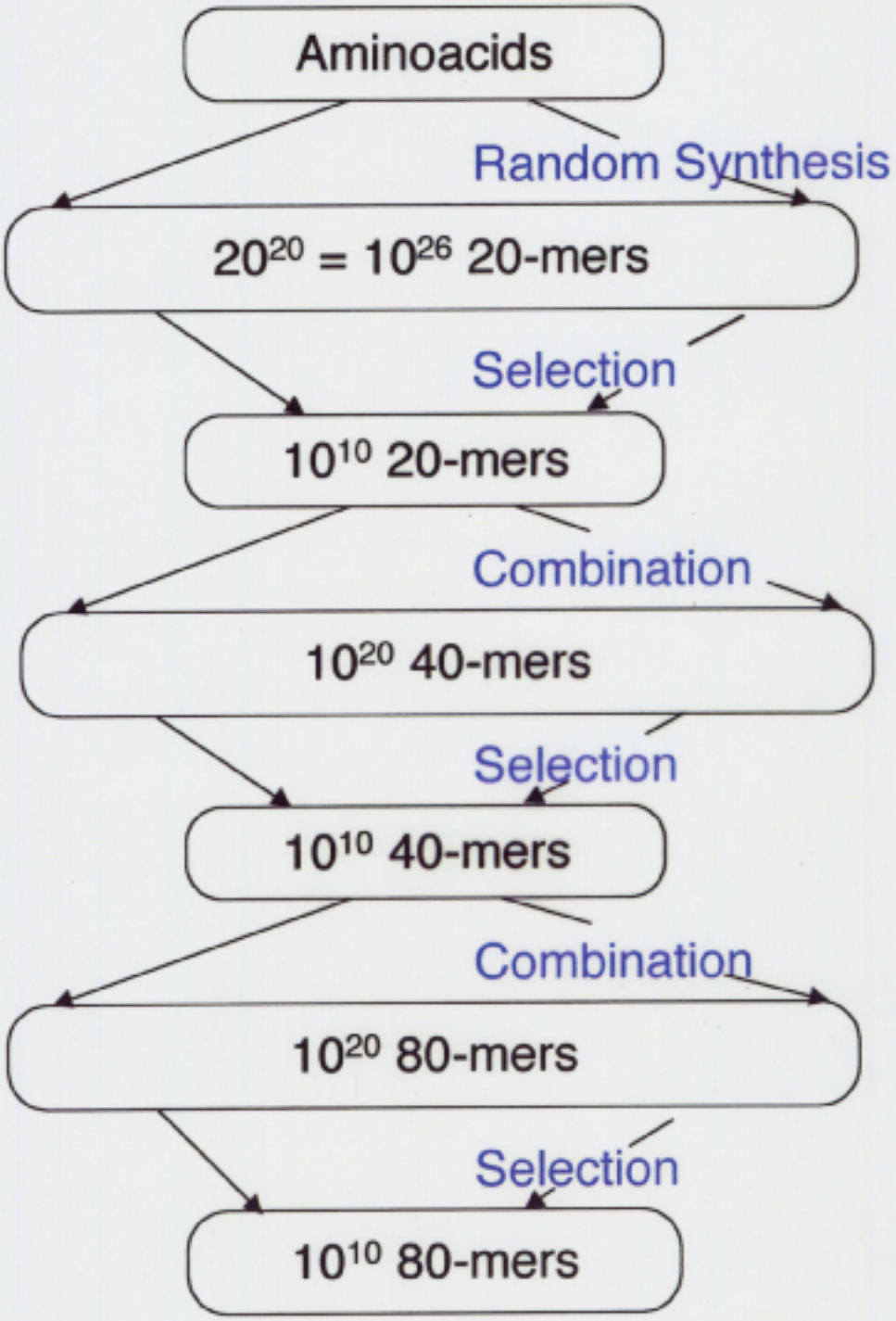
B) THE FIRST PROTEINS WERE NO MORE THAN ABOUT 20 AMINO ACIDS LONG

Assuming RNA Genes of about 70 Nucleotides, 60 Translatable (1.43% Replication Error)

C) PEPTIDES 20 AMINO ACIDS LONG CAN DISPLAY CATALYTIC ACTIVITIES

THE BIRTH OF PROTEINS

(by way of RNA genes)



CHANCE DOES NOT EXCLUDE INEVITABILITY

Let ***P*** be the probability of an event

not taking place.

Then the probability ***P'*** of the event

actually taking place = $1 - P^n$,

in which ***n*** is the number of trials.

Examples

GAME	PROBABILITY ***P'*** FOR ***n***=1	VALUE OF ***n*** FOR ***P'***=99.9%
Toss of a Coin	1/2	10
Throw of a Die	1/6	38
Roulette (1 zero)	1/37	252
Lottery (7 digits)	$1/10^7$	69×10^6
Point Mutations (replication errors)	$1/(3 \times 10^9)$ per cell division	20×10^9 divisions

Probability of finding a given point mutation

in a clone is 99.9% after about

34 generations (less than one day

for bacteria; about one month

for eukaryotic cells).

In red blood cell formation in a human

adult,

it takes about 2 hours for any given

point mutation

to occur with a 99.9% probability.

Examples

Antibiotic-resistant bacteria

Chloroquine-resistant plasmodia (malaria)

DDT-resistant mosquitoes

Herbicide-resistant weeds

Dark/light English moths

Animal mimicry

Land adaptation of marine animals ?

Hominization ?

Convergent Evolution
